

Claims

The following listing of claims will replace all prior versions, and listings, of claims in the present application:

1. (Previously presented) A method of reducing an amount of carbon monoxide in process fuel gas in a water gas shift converter, comprising:

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; a mixed metal oxide support consisting essentially of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 58% to about 80% by weight of mixed metal oxide and zirconium oxide is present in amount from about 42% to about 20% by weight of mixed metal oxide; and a promoter comprising yttrium, alkali metals, or alkaline earth metals, or combinations thereof; and

passing the process fuel gas through the water gas shift converter in effective contact with the high activity water gas shift catalyst system and converting a portion of the carbon monoxide in the process fuel gas into carbon dioxide and hydrogen by a water gas shift reaction.

2. (Original) The method of claim 1 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

3. (Original) The method of claim 1 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

4. (Original) The method of claim 1 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, yttrium, or combinations thereof.

5. (Original) The method of claim 1 wherein the promoter is present in an amount of between about 0.1% and about 1% by weight of total catalyst.

6. (Original) The method of claim 1 wherein the mixed metal oxide support further comprises a support dopant.

7. (Original) The method of claim 6 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

8. (Original) The method of claim 6 wherein the support dopant is in the form of a metal oxide.

9. (Original) The method of claim 6 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

10. (Original) The method of claim 1 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 400°C.

11. (Original) The method of claim 1 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 250°C to about 375°C.

12. (Original) A method of reducing an amount of carbon monoxide in process fuel gas in a water gas shift converter, comprising:

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; and a mixed metal oxide support of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 20% to less than 58% by weight of mixed metal oxide and zirconium oxide is present in amount from more than 42% to about 80% by weight of mixed metal oxide; and

passing the process fuel gas through the water gas shift converter in effective contact with the high activity water gas shift catalyst system and converting a portion of the carbon monoxide in the process fuel gas into carbon dioxide and hydrogen by a water gas shift reaction.

13. (Original) The method of claim 12 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

14. (Original) The method of claim 12 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

15. (Previously presented) The method of claim 12 wherein the high activity water gas shift catalyst system further comprises a promoter comprising at least one metal selected from yttrium, alkali metals, or alkaline earth metals.

16. (Original) The method of claim 15 wherein the promoter is selected from yttrium, cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

17. (Original) The method of claim 15 wherein the promoter is present in an amount of between about 0.1% and about 1% by weight of total catalyst.

18. (Original) The method of claim 12 wherein the mixed metal oxide support further comprises a support dopant.

19. (Original) The method of claim 18 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

20. (Original) The method of claim 18 wherein the support dopant is in the form of a metal oxide.

21. (Original) The method of claim 18 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

22. (Original) The method of claim 12 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 400°C.

23. (Original) The method of claim 12 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 250°C to about 375°C.

24. (Original) A method of reducing an amount of carbon monoxide in process fuel gas in a water gas shift converter, comprising:

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; a mixed metal oxide support consisting essentially of cerium oxide and lanthanum oxide; and optionally a support dopant; and

passing the process fuel gas through the water gas shift converter in effective contact with the high activity water gas shift catalyst system and converting a portion of the carbon monoxide in the process fuel gas into carbon dioxide and hydrogen by a water gas shift reaction.

25. (Original) The method of claim 24 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

26. (Original) The method of claim 24 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

27. (Original) The method of claim 24 wherein cerium oxide is present in an amount from about 92% to about 20% by weight of mixed metal oxide and lanthanum oxide is present in amount from about 8% to about 80% by weight of mixed metal oxide.

28. (Original) The method of claim 24 wherein the high activity water gas shift catalyst further comprises a promoter comprising at least one metal selected from yttrium, alkali metals, or alkaline earth metals.

29. (Original) The method of claim 28 wherein the promoter is selected from yttrium, cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

30. (Original) The method of claim 28 wherein the promoter is present in an amount of between about 0.1% and about 1% by weight of total catalyst.

31. (Original) The method of claim 24 wherein the support dopant is selected from praseodymium, neodymium, or combinations thereof.

32. (Original) The method of claim 24 wherein the support dopant is in the form of a metal oxide.

33. (Original) The method of claim 31 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

34. (Original) The method of claim 24 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 425°C.

35. (Original) The method of claim 24 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 275°C to about 400°C.

36. (Previously presented) A high activity water gas shift catalyst system, comprising:
a noble metal;
a mixed metal oxide support consisting essentially of cerium oxide and zirconium oxide, wherein the cerium oxide is present in an amount from about 58% to about 80% by weight of mixed metal oxide and the zirconium oxide is present in amount from about 42% to about 20% by weight of mixed metal oxide; and
a promoter comprising yttrium, alkali metals, or alkaline earth metals, or combinations thereof.

37. (Original) The high activity water gas shift catalyst system of claim 36 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

38. (Original) The high activity water gas shift catalyst system of claim 36 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

39. (Original) The high activity water gas shift catalyst system of claim 36 further comprising a support dopant.

40. (Original) The high activity water gas shift catalyst system of claim 39 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

41. (Original) The high activity water gas shift catalyst system of claim 39 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

42. (Original) The high activity water gas shift catalyst system of claim 36 wherein the promoter is selected from yttrium, cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

43. (Original) The high activity water gas shift catalyst system of claim 36 wherein the promoter is present in an amount of between about 0.1% and about 1% by weight of total catalyst.

44. (Original) A high activity water gas shift catalyst system comprising:

a noble metal; and

a mixed metal oxide support of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 20% to less than 58% by weight of mixed metal oxide and zirconium oxide is present in amount from more than 42% to about 80% by weight of mixed metal oxide.

45. (Original) The high activity water gas shift catalyst system of claim 44 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

46. (Original) The high activity water gas shift catalyst system of claim 44 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

47. (Original) The high activity water gas shift catalyst system of claim 44 further comprising a support dopant.

48. (Original) The high activity water gas shift catalyst system of claim 47 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

49. (Original) The high activity water gas shift catalyst system of claim 47 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

50. (Original) The high activity water gas shift catalyst system of claim 44 further comprising a promoter comprising at least one metal selected from yttrium, alkali metals, and alkaline earth metals.

51. (Original) The high activity water gas shift catalyst system of claim 50 wherein the promoter is selected from yttrium, cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

52. (Original) The high activity water gas shift catalyst system of claim 50 wherein the promoter is present in an amount of between 0.1% and about 1% by weight of total catalyst.

53. (Original) A high activity water gas shift catalyst system comprising:
a noble metal; and
a mixed metal oxide support consisting essentially of cerium oxide and lanthanum oxide;
and
optionally a support dopant.

54. (Original) The high activity water gas shift catalyst system of claim 53 wherein cerium oxide is present in an amount from about 20% to less than 92% by weight of mixed metal oxide and lanthanum oxide is present in amount from about 80% to more than 8% by weight of mixed metal oxide.

55. (Original) The high activity water gas shift catalyst system of claim 53 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

56. (Original) The high activity water gas shift catalyst system of claim 53 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

57. (Original) The high activity water gas shift catalyst system of claim 53 wherein the support dopant is selected from praseodymium, neodymium, or combinations thereof.

58. (Original) The high activity water gas shift catalyst system of claim 53 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

59. (Original) The high activity water gas shift catalyst system of claim 53 further comprising a promoter comprising at least one metal selected from yttrium, alkali metals, and alkaline earth metals.

60. (Original) The high activity water gas shift catalyst system of claim 59 wherein the promoter is selected from yttrium, cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

61. (Original) The high activity water gas shift catalyst system of claim 59 wherein the promoter is present in an amount of between 0.1% and about 1% by weight of total catalyst.